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Docket No. AM1562D1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF APPEALS AND INTERFERENCES

In re Application of

YIQIONG WANG — Confirmation No. 8856

Serial No.: 09/882,141 — Examiner: Umez-Eronini

Filed: June 15, 2001 — Group Art Unit: 1765

For: METHOD OF ETCHING HIGH ASPECT RATIO OPENINGS IN SILICON

BRIEF ON APPEAL

To: Assistant Commissioner for Patents
Washington, DC 20231

Sir:

This is an appeal from a Final Rejection dated May 15, 2002. A Notice of Appeal was filed October 10, 2002 together with a Petition for a two month extension of time to October 16, 2002. Three copies of this Brief are attached. The fee for filing the Brief is to be charged to Deposit Account 13-4542.

(1) REAL PARTY IN INTEREST

The real party in interest in this application is Applied Materials, Inc of 3050 Bowers Avenue, Santa Clara, CA 95054, the assignee of 100% of the interest in this application.

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(2) RELATED APPEALS AND INTERFERENCES

This is a divisional application. The parent application, Serial No. 08/867,229, has also been finally rejected and appealed. A Brief on Appeal in that application was filed on November 14, 2002.

(3) STATUS OF CLAIMS

The claims are 1=6. Claim 4 has been allowed. Claims 1-3 and 5-6 have been finally rejected. Claim 1 was amended in a response filed under 37 CFR 1.115. No amendments were proffered after Final Rejection.

(4) STATUS OF AMENDMENTS

Claims 1 and 4 were amended in response to a non-final rejection dated October 12, 2001. No further amendments have been made to the claims.

(5) SUMMARY OF THE INVENTION

The present invention is directed to an etch mixture that can anisotropically etch a silicon substrate in a plasma etch chamber when the substrate is connected to a low power (400 kHz) bias source. The etch mixture contains one or more fluorine-containing etch gases. selected from SF_6, Si_2F_6 and SiF_4, together with HBr and oxygen. The silicon openings obtained using this

etchant while applying a bias during the etch, have a high aspect ratio; straight walls and rounded bottoms; they have a high etch rate; and excellent uniformity across the silicon substrate. Further, the etchant has a selectivity to a silicon oxide mask of up to 23.

(6) THE ISSUES

1) Whether claims 1-3 are anticipated by Komura et al, (US Patent 5,423,941).

2) Whether claims 1-3 are obvious over Komura et al in view of Harshbarger et al (US Patent 4,208,241).

3) Whether claims 5 and 6 are unpatentable over Komura et al.

(7) GROUPING OF CLAIMS

Claims 1-3 will be considered together regarding Issues 1) and 2). Claims 5 and 6 will be grouped and discussed together.

(8) THE REJECTIONS

Claims 1-3 have been rejected as anticipated by Komura et al. The Examiner concedes that Komura et al do not show biasing the substrate but she does not give that feature patentable weight. Further the Examiner has dismissed the claimed requirement of anisotropy for the etchant for this anticipation

rejection.

Claims 1-3 have also been rejected as obvious or unpatentable over Komura et al and Harshnarger et al. Harshbarger et al teaches that an anisotropic etch results in flat, vertical walls on a plane approximately that of the initial patterned mask edge prior to etching, similar to the trench of Komura et al shown in Fig. 1A. Thus one skilled in the art, according to the Examiner, practicing the etch of Komura et al, would produce an anisotropic etch.

Claims 5-6 require certain volume ratios of the etchant ingredients. However, the Examiner states it would have been obvious at the time the invention was made to employ any of a variety of processing variables such as those claimed by appellants, and that optimization of an etchant by changing temperature, concentration or other process conditions do not impart patentability unless they produce a new and unexpected result.

(9) THE ARGUMENTS

The First Issue

Claims 1-3 have been rejected as anticipated by Komura et al. Komura et al disclose a plasma etch gas mixture of a bromine-

containing gas, a cleaning gas, which can be a halogen gas, particularly a fluorine-containing gas, and a reactive gas, including oxygen, preferably diluted. Komura et al, as conceded by the Examiner, does not bias the substrate during etching.

However, using the claimed etch mixture, a conformal, fluorine-containing polymer forms on the sidewalls and the bottom of the opening being etched, The result is that the silicon, where covered by the fluorine-containing polymer, is no longer attacked by the etchant. The polymer that forms on the bottom of the opening however, stops or slows anisotropic etching on the bottom, preventing the formation of high aspect ratio openings.

However, as a result of biasing the substrate, this polymer is precluded from depositing on the bottom of the openings, so that etching can continue at the bottom of the opening, at least until all of the silicon at the bottom of the opening has been etched away. This is a great advantage in terms of the aspect ratio achievable.

Anticipation is only established when a single prior art reference discloses, expressly or under the principals of inherency, each and every element of a claimed invention. See Kalman v Kimberly-Clark Corp, 218 USPQ 781 (CAFC 1983), affirmed

in RCA Corp v Applied Digital Data Systems, Inc, 221 USPQ 385 at 388, (CAFC 1984).

The element of a biased silicon substrate, as required by claims 1-3, is not disclosed by Komura et al; thus appellant submits the invention of claims 1-3 is not anticipated by Komura et al.

Komura et al do not disclose biasing the substrate during etching. The Examiner wants to dismiss this requirement of the claims, but it has important results on the behavior of the etchant and the aspect ratio of the etched openings achievable, and thus appellant submits it must be considered as part of the invention claimed. By biasing the substrate electrode, etching can be continued to very high aspect ratios - i.e., the ratio of the length to the width of the opening. Since the sidewalls of the openings are protected from the etchant by the deposition of a hard, polytetrafluoroethylene-type, etchant-impervious polymer on the sidewalls, but not protected at the bottom of the openings, etching can continue at the bottom of the openings without causing damage or wear on the sidewalls of the etched opening in silicon, or the mask layer. Thus very small diameter openings can be made to deep depths. Thus appellant submits

Komura et al do not anticipate the present claims.

The Second Issue

Komura et al do not disclose the deposition of a polymer of fluorine on the sidewalls of etched openings. They do disclose the deposition of "residue" or "adhering reaction products" to the opening, but teach away from doing that. Thus Komura et al do not render the present claims obvious either. Thus the Examiner has combined this reference with Harshbarger et al to make an obviousness rejection.

The Harshbarger et al reference is a general disclosure discussing the production of both etchant species and recombinant species. By changing the production rates, various profiles can be obtained in openings in, for example, silicon. Halogen etchants are disclosed, which can be combined with fluorocarbons such as CF_3 as a recombinant material; neither HBr nor oxygen are discussed as etchants, as required by the present claims. Further, there is no recognition or teaching of how to obtain high aspect ratio openings using a bias during etching. In addition, the etch rates disclosed were low - the highest etch rate obtained by Harshbarger et al for an anisotropic etch was 800 angstroms/min, as contrasted to the more than double etch

rate of 1.7 microns/min achieved by appellant. Thus appellant submits Harshbarger et al does not supply the etchant species required in the present claims nor disclose or suggest applying a bias to the substrate, features required by the present claims that are missing from Komura et al. Thus appellant submits that even when these references are considered together, the present claims are not rendered obvious.

The Third Issue

Claims 5-6 have been rejected as unpatentable over Komura et al. The Examiner concedes that the volume ratios called for in claims 5 and 6 are not disclosed in Komura et al. Claim 5 requires a volume ratio of HBr:SF_6 of 0.1-10. Claim 6 requires a volume ratio of HBr and SF_4:O_2 of 0.1-10. The volume ratios of these etchant ingredients given in Komura et al's sole example are higher than the maximum of 10 as called for in both of these claims.

The Examiner states it would be obvious to employ any of a variety of different processing variations. However, Komura et al do not tell which variations to choose in order to obtain the high aspect ratio and high etch rates of appellant and does not suggest, as conceded by the Examiner, that applying a bias to the

substrate is one of such possible variations. Harshbarger et al also discuss various parameters subject to control, see col. 8 lines 17-25, but bias to the substrate is not one of them.

Further, in their sole example, the etch gas ratios used by Komura et al do not obtain the etch rates achieved by appellant. In Example 11, openings 20 microns deep were made, but the width of the opening, which would be required to determine the aspect ratio, is not disclosed. Thus appellant submits one skilled in the art would not know from Komura et al whether the etch rates and aspect ratios obtained by appellant could be achieved at all, or which variables to alter to achieve such results. The volume ratios of the etchant gases as claimed are lower than those shown by Komura et al.

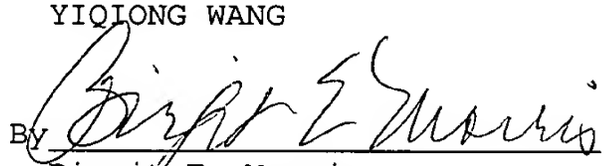
SUMMARY

Appellant has succeeded in obtaining very high aspect ratio, small diameter anisotropic openings in silicon at high etch rates, by choosing particular etchant mixtures and biasing the substrate during the etch. The prior art does not suggest that these results can be achieved, or how. Thus appellant submits the prior art neither anticipates nor renders obvious the claimed etchant combinations.

In view of the above discussion, appellant submits the present claims are in condition for allowance. Accordingly, reversal of the rejections and allowance of the claims are respectfully solicited.

Respectfully submitted,

YIQIONG WANG

By 

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APPENDIX

1. An anisotropic etch mixture for a silicon substrate connected to a low power bias source consisting of one or more of a fluorine-containing gas selected from the group consisting of SF_6, Si_2F_4 and SiF_4, and HBr and oxygen.

2. An etch mixture according to claim 1 wherein the mixture additionally includes a noble gas.

3. An etch mixture according to claim 1 wherein the mixture contains SF_6.

4. An etch mixture for silicon consisting essentially of a fluorine-containing gas that includes SF_6, Si_2F_4, and SiF_4, HBr and oxygen.

5. An etch mixture according to claim 3 wherein the volume ratio of HBr:SF_6 is 0.1 to 10.

6. An etch mixture according to claim 3 wherein the volume ratio of HBr and SF_4:O_2 is 0.1 to 10.